THE GROWTH PATTERN OF OTOLITHS OF *LOPHIUS PISCATORIUS* L., 1758 AND *LOPHIUS BUDEGASSA* SPINOLA, 1807 IN THE AEGEAN SEA

by

Nikolaos TSIMENIDIS (1)

ABSTRACT. – Otoliths of *Lophius piscatorius* L., 1758 and *L. budegassa* Spinola, 1807 were examined for their development and growth pattern. Considering the development of these otoliths in relation to their shape at the two extremities and their natural position, it has been found that the otoliths of *L. piscatorius* grow faster towards the pointed rim while those of *L. budegassa* grow faster towards the curved rim. However, since the pointed rim of the former species as well as the curved rim of the latter one face anteriorly, it has been shown that the rapidity of otolith growth in both species is significantly higher towards the anterior end.

RESUME. – On a examiné le développement et le mode de croissance des otolithes de *Lophius piscatorius* L., 1758 et *L. budegassa* Spinola, 1807. Si l'on considère le développement de ces otolithes en fonction de la forme de leurs extrémités et de leur position naturelle, on voit que les otolithes de *L. piscatorius* croissent plus vite vers le bout pointu tandis que ceux de *L. budegassa* croissent plus vite vers le bout arrondi. Comme le bout pointu de la première espèce et le bout arrondi de la deuxième sont placés en avant, on en déduit que la vitesse de croissance des otolithes chez les deux espèces est plus grande à l'extrémité antérieure.

Key-words : Med Aegean, Pisces, Lophiidae, Lophius piscatorius, Lophius budegassa, otoliths, growth.

Various researchers have described the otoliths of *L. piscatorius* L., 1758 and *L. budegassa* Spinola 1807 (Frost, 1928; Chaine and Duvergier 1934; Schmidt 1968; Tsimenidis, 1980) but nothing has been done in studying the pattern of their growth towards the anterior, posterior, dorsal and ventral directions.

In the course of development of otoliths of the Mediterranean two Lophiids it was noticed that, apart from the variation of their general appearence, the rapidity of growth, mainly towards the two extremities, varied remarkably in these species.

The purpose of this paper is to study the pattern of otolith growth of the two species of the genus *Lophius* L. present in the Aegean Sea.

MATERIAL AND METHODS

Samples were collected from two sources : research samples taken aboard by a research otter trawler and from commercial landings.

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(1) Institute of Oceanographic and Fisheries Research, Aghios Kosmas-Hellinikon - GREECE.

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A total of 288 individuals of the angler fish *L. piscatorius* were taken mainly from landings in various fish markets along the greek coasts during 1976-1979, and 626 individuals of *L. budegassa* were taken from the Saronikos Gulf in 1976-1977.

The reason for taking different sample sizes of the two forementioned anglerfishes and from various sample sites was that *L. piscatorius* in much less common than *L. budegassa* in the Aegean Sea (Tsimenidis and Ondrias, 1980).

Both otoliths were removed and preserved in glycerine. Since the otoliths from both sides were almost identical (Tsimenidis, 1980), the right side otolith from *L. piscatorius* and the left side one from *L. budegassa* were arbitrarily chosen for examination.

The otoliths were examined whole immersed in 90 % alcohol with their inner surfaces upward against a dark background with the ventral rim towards the observer, and illuminated with reflected light. In this position the nucleus was evident in all *L. budegassa* otoliths and in the small and medium size ones (length along the antero-posterior axis, DA = 1.84 - 6.00 mm long) of *L. piscatorius*, because of their raised central portion of the inner side, which becomes thicker as the otolith grows. Thus, the *L. piscatorius* otoliths longer than 6.0 mm were viewed with their outer side upward.

The various measurements taken for each otolith are shown in Fig. 1.

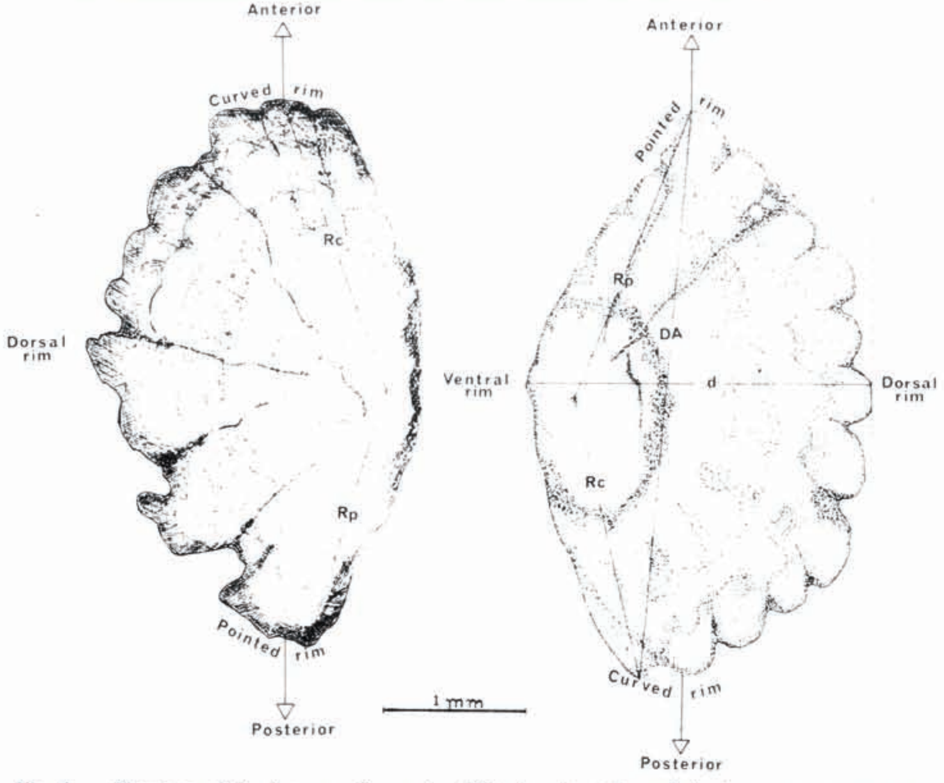


Fig. 1. – Drawings of the inner surfaces of otoliths (sagittas) from *L. budegassa* (left) and *L. piscatorius* (right) showing the measurements taken; DA = otolith length, Rc = radius towards the curved rim, Rp = radius towards the pointed rim, d = otolith width.

RESULTS AND DISCUSSION

Growth pattern of the *L. piscatorius* otolith

The otolith of the smallest fish examined (120 mm long) measured 1.84 mm in length. It was pear-shaped with the dorsal rim slightly dentated and the ventral edge curved.

The beginning of the formation of a rostrum can be seen in the otoliths of some fish of the 120-130 mm length group (Fig. 2a). In the course of otolith development, its growth pattern, particularly towards the two extremities, gradually changes.

During the first stage of growth, which lasts until the otolith reaches an average length of about 5.1 mm, the distance of nucleus from the two extremities, viz the lengths of Rp (pointed rim) and Rc (curved rim), is in favor of Rc for the same otolith length, whereas, during the second stage of development, namely for otoliths longer than 5.1 mm, this ratio gradually changes to Rp ⟩ Rc, with the difference of the two terms increasing as they rise (Fig. 3).

During the growth procedure, the otolith becomes gradually pointed towards the anterior rim (rostrum) and rounded towards the posterior edge (Fig. 2a-2d).

In the same time the otolith grows towards the dorsal and ventral rims. The rapidity of growth is higher towards the dorsal than the ventral edge.

Seen in its natural position a sagitta of *L. piscatorius* longer than 5.1 mm is an irregularly shell-shaped body, usually tapering anteriorly and rounded posteriorly.

It is shown that the rapidity of growth towards the pointed rim is generally higher than to the rounded rim. The difference in length of the two radii increases continuously along with the increase of the otolith length.

As a consequence of this comspicuous feature, the otolith finally has a much longer Rp than and Rc.

Growth pattern of the *L. budegassa* otolith

The otolith of the smallest fish examined (47 mm long) measured 1.20 mm. It was oval in shape and divided into petal-like sections (Fig. 2e). At this stage of development the radii Rp and Rc differed very little in favor of the Rp.

Growth in length and width of the otolith is accomplished with changes of the general appearance. Gradually the otolith becomes tapered to a point posteriorly and blunty rounded anteriorly. The ventral rim is remained slightly curved while the dorsal rim successively becomes more and more dentated, so that most of the largest otoliths examined had their dorsal edge very deeply and irregularly excavated.

As the otolith grows, the length ratio of Rp and Rc gradually changes (Fig. 2e-2h). The difference in length of the radii in this species is much less apparent than in the *L. piscatorius* otoliths, however, it is obvious that during the first stage of development, which lasts roughly up to an otolith length of 4.2 mm, Rp is in average longer than Rc. In otoliths ranging from 4.2 to 5.8 mm long the two radii

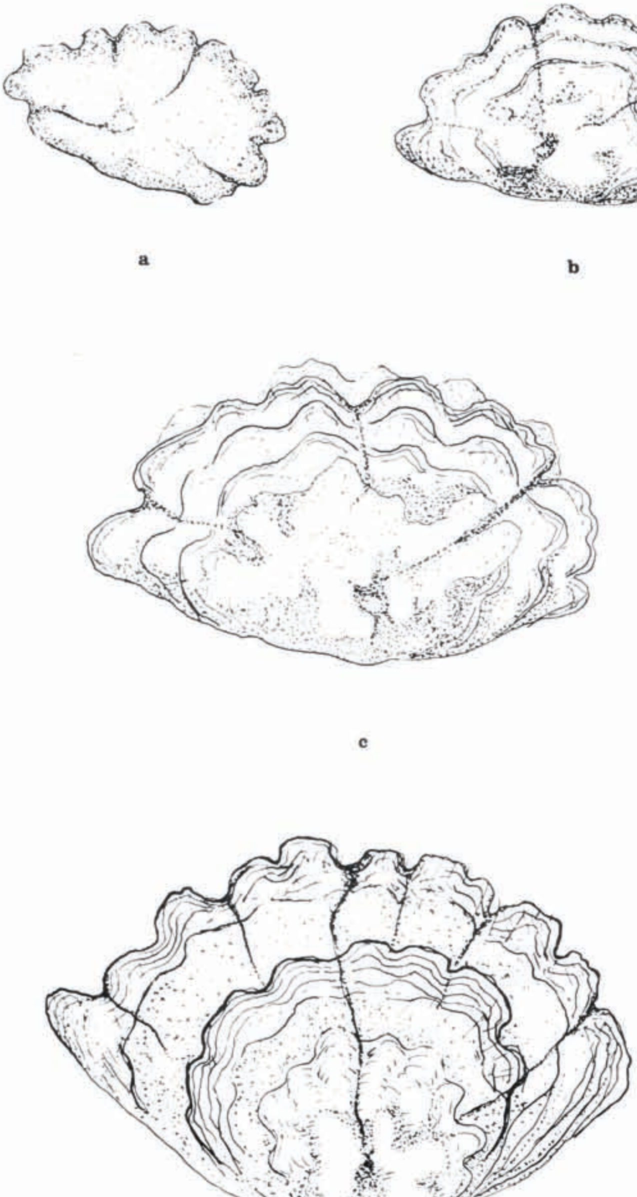
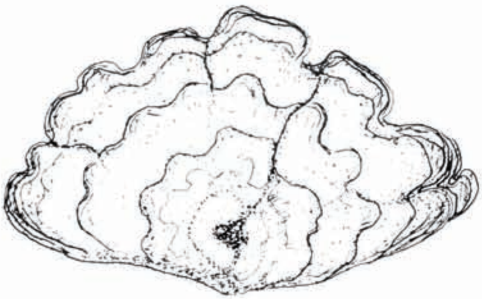


Fig. 2. – Diagrammatic drawings of the inner surfaces of otoliths from *L. piscatorius* (a - d) and *L. budegassa* (e - h) in various development stages with special reference to the change in shape and radii growth towards the pointed and curved rims.

e

f



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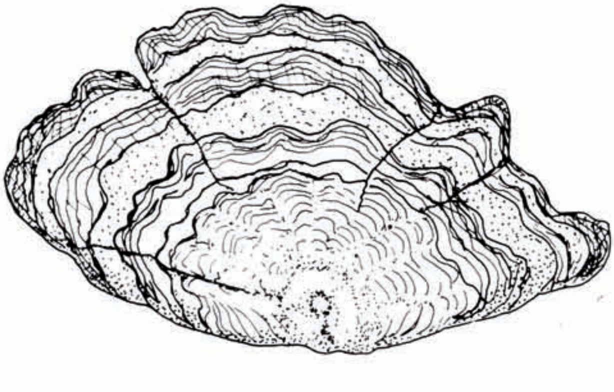

h

are of about equal size while for otoliths longer than 5.8 mm the radii ratio starts changing inversely, and finally the ratio becomes Rp ‹ Rc with the difference of the two terms increasing as they rise.

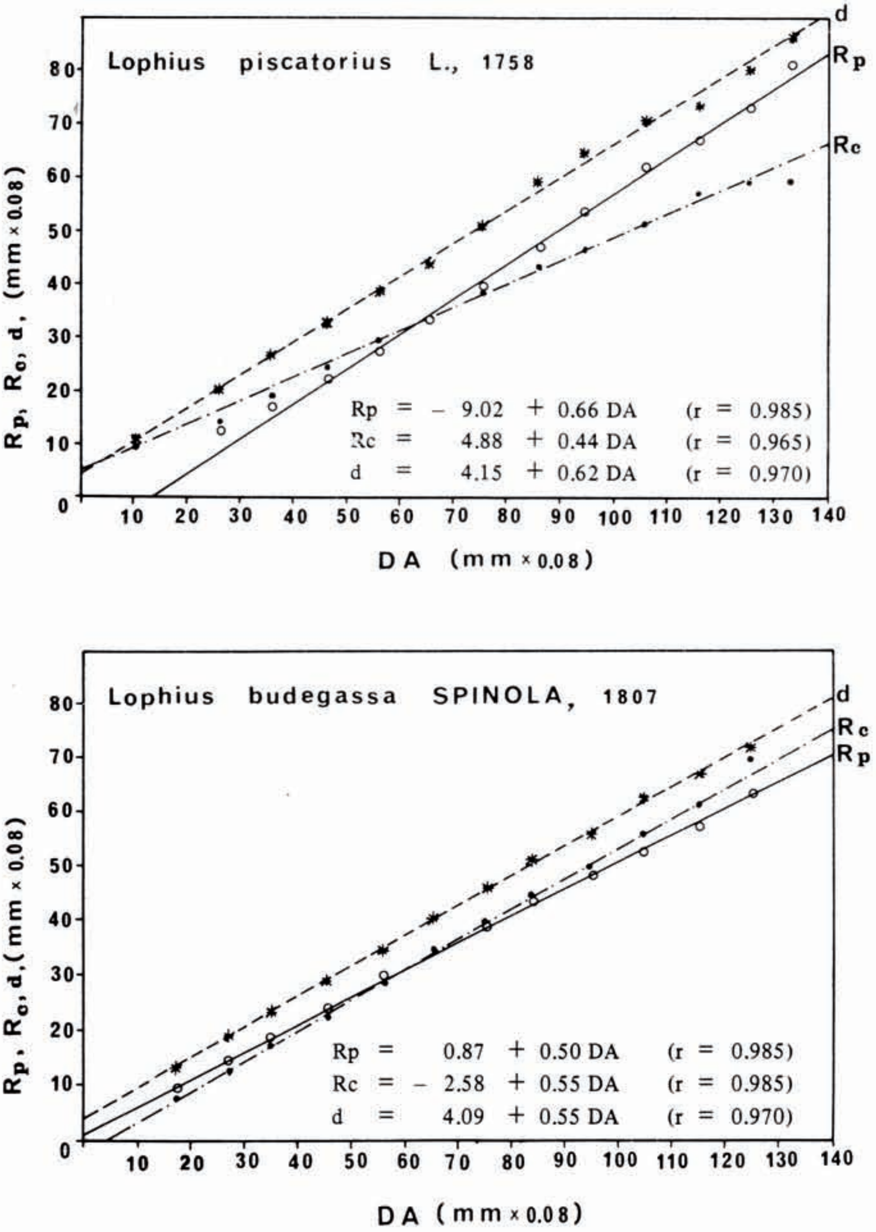

Fig. 3. – Scatter diagram of the means of radii and width versus otolith length and superimposed regression lines.

Comparison of otolith growth patterns

The growth of fish otoliths differs according to the part studied, consequently the growth is faster along the antero-posterior axis and is different between the two extremities (Irie, 1960).

This conspicuous feature was examined in connection with the natural position of the otolith in the Lophiids under consideration.

Seen in its natural position a *L. piscatorius* otolith of medium size, it is tapering anteriorly and bluntly rounded posteriorly, while a same size otolith of *L. budegassa* is curved anteriorly and pointed posteriorly (Fig. 2).

As mentioned the rate of otolith growth from nucleus towards the pointed (Rp) and curved (Rc) rims shows a distinct variation in the two species. According to this, the radius Rp progressively becomes longer than the Rc in *L. piscatorius*, while the radius Rc gradually becomes longer than the Rp in *L. budegassa.*

As a consequence of the different rate of growth towards the two extremities in relation with the natural position of the otoliths, it was found that the otoliths of the two Lophiids grow more rapidly towards their anterior rim than to the posterior. Comparing the lengths of the anteriorly directed otolith radii in the two species, it has been shown that the rapidity of growth of the Rp for *L. piscatorius* is much higher than of the Rc for *L. dubegassa*. A statistical comparison indicated that the difference of the adjusted means was highly significant ($P < 0.001$).

Apart from the difference in growth pattern towards the two extremities a basic variation was also noticed in the rate of growth of otolith width(d) between the two species.

For both species of the genus *Lophius*, the annual growth was studied by backcalculating on the basis of otolith-body length relationship (Tsimenidis, 1980). The distance from the centre of the otolith to each annulus was measured along the Rp for *L. piscatorius* and the Rc for *L. budegassa*. The observed relatively higher rate of growth of Rp for the former species as compared with Rc for the latter is confirmed also in absolute values by comparing the lengths of these radii for each annulus (Fig. 4).

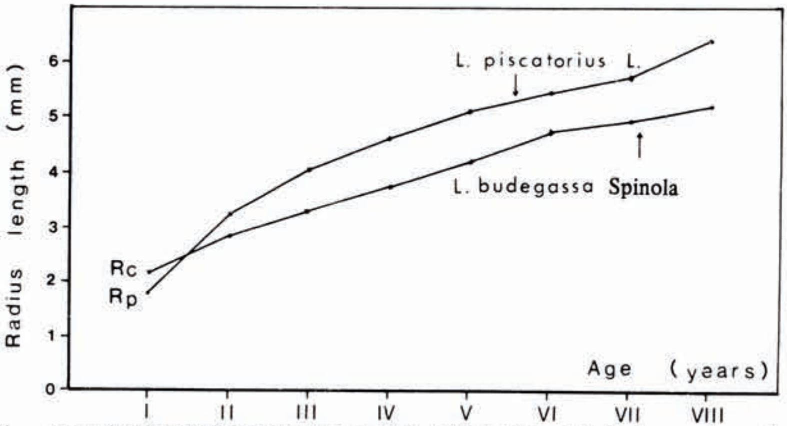

Fig. 4. – Growth of otolith radii versus age of *L. piscatorius* and *L. budegassa* from the Aegan Sea.

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